

VERTICAL UNMANNED AIRCRAFT SYSTEM ALTERNATIVE FOR THE F-35B JSF

BY

LIEUTENANT COLONEL JAMES FREY
United States Marine Corps

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U.S. Army War College, Carlisle Barracks, PA 17013-5050

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by

Lieutenant Colonel James Frey
United States Marine Corps

Colonel Phil Tissue
Project Adviser

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U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

ABSTRACT

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The U.S. Marine Corps has much at stake with the F-35B Short Takeoff and Landing (STOVL) version of the Joint Strike Fighter. In a strategic gamble, the Corps has shaped an amphibious force around the technology and capabilities promised by this program. To support the nation's expeditionary force in readiness, the conceptual capabilities of this platform will continue to provide a unique and powerful piece of the Marine Air Ground Task Force (MAGTF). Facing an uncertain future, the Marine Corps continuously defends its fixed-wing strike/fighter programs within the Naval Aviation community and the Department of Defense. Little has been published on alternatives to this aircraft. This SRP analyzes the capabilities of STOVL, recommends a future course of action, and champions the use of a Vertical Unmanned Aerial System to enhance the MAGTF.

VERTICAL UNMANNED AIRCRAFT SYSTEM ALTERNATIVE FOR THE F-35B JSF

Airpower is the preferred means for the United States to utilize military power because it can deliver bytes, bombs, bullets, bread, or bodies to the combat theater, from a distance, at high speed, and with great accuracy. In so doing, it has a high ratio of potential strategic success to lives risked, both friendly and hostile. If one has to fight a war, this seems to be the preferred way to do so. Demonstrating the continued capacity to do so is an investment in forestalling war rather than fighting one.

—Grant T. Hammond (2005)

Background—Strategic Risk for the Joint Strike Fighter

By 2024 the F-35 Lightning II Joint Strike Fighter (JSF) is expected to replace the current inventory of Marine Corps tactical aircraft (TACAIR).¹ Once the transitions from the AV-8B Harrier II, F/A-18C/D Hornet, and E/A-6B Prowler are complete, the Marines will operate with a single fighter or attack aircraft for the first time in nearly 100 years.² The Marines are counting on the advertised reliability of the JSF and industrial competence to validate this single-platform solution. At an estimated cost of \$382 billion, the JSF is the most expensive American weapons program ever.³ The armed forces of the United States will rely on this platform to project the nation's backbone of tactical aircraft power. There is much at stake in the nation's reliance on a singular platform to defeat potential military adversaries. Further, looming fiscal realities will undoubtedly shape future U.S. military procurement. For the Marines, these concerns are more pressing because they have been leading the U.S. Air Force and U.S. Navy in this all-in endeavor. In view of these uncertainties, the Marine Corps has an opportunity to reduce risk inherent in this joint endeavor. Risk can be mitigated with the development and integration of a Vertical takeoff-and-land Unmanned Aircraft System (VUAS) to complement the JSF.

The JSF Plan

The F-35B, the Short Take Off and Landing (STOVL) version designed for the Marine Corps, was slated for an initial operating capability (IOC) demonstration in December 2012. This date has been moved indefinitely to the right according to General James Amos, Commandant of the Marine Corps.⁴ Recommendations to terminate the more costly and technologically challenging Marine F-35B were among recent proposals from the President's recent Deficit Reduction Commission Report.⁵ In January 2011, the Secretary of Defense ordered a pause in production for the F-35B and granted the Marine Corps a two-year probationary period to finish development of the STOVL JSF.⁶ To put it plainly, Secretary Gates recommends cancelling the F-35B if it fails to meet its performance objectives and production timelines.

The STOVL version reflects delays in the entire program of the three variants depicted in Table 1. The Air Force extended the IOC for its version, the F-35A, from June 2011 to April 2016; the Navy delayed the IOC of the F-35C (aircraft carrier variant) from April 2012 to April 2016.⁷ These extensions increasingly pressure the Marines tactical community. A two-year extension exacerbates issues regarding the current aircraft service life—the F/A-18Cs will average 22 years, the EA-6Bs will average 31 years, the AV-8B's will average 17 years. Compounding the aging of these aircraft has been the high tempo of flight hours starting with Operation Iraqi Freedom (OIF) and continuing through Operation Enduring Freedom (OEF). Deployed squadrons often flew at a rate of 3.5 – 4.0 times their planned usage, thereby reducing the useful years left on airframes. In fact, the Marine Corps has used up available F/A-18C/D inventory and removed two squadrons from the flight line due to lack of aircraft. This operational

decision has obvious strategic implications. These squadrons are in a cadre status awaiting the arrival of the JSF.

Marine Corps leaders assumed some calculated risk by not investing in the F/A-18E/F Super Hornet to replace the aging legacy F/A-18 Hornet. The improved Hornet, to include the Electronic Attack E/A-18G Growler, would replace only two of the three platforms—completely missing the STOVL requirement for the Harrier mission and amphibious ship suitability. Also, money spent on a design that has been in production for over thirty years does not yield the benefits of a 5th-generation stealth fighter/attack aircraft. This is similar to buying the vaunted P-51D Mustang in the mid-1970s instead of the F-15 Eagle. Instead, aviation leaders have stayed the course on JSF while focusing efforts and resources on the critical transitioning of other legacy platforms to new ones. Currently, Marine Aviation is transitioning the UH-1Y Venom, UH-1Z Viper, KC-130J Hercules, and MV-22B Osprey. In spite of this, the Marines' F/A-18A/C/Ds continue to expend a finite amount of their remaining service life.

The Navy, anticipating the same strike fighter shortfalls, mitigates the problem by purchasing 515 Super Hornets to keep the aircraft wings aboard the carrier decks full.⁸ Interestingly, Navy leadership sees the F-35C replacing the F/A-18 A/B/C/D and complementing—but not replacing—the F/A-18E/F. Their program of record for 2032 seeks an aircraft called the F/A-18E/F Replacement. Finally, the JSF delays will leave the Navy short from a low of 100 fighters to a high of 177 by 2017.⁹

The U.S. share of the JSF program is estimated at over 2400 aircraft.¹⁰ However, the recent track record on what the Department of Defense (DoD) has received to what was planned renders this projection as unrealistic. The planned purchase of 750 F-22

Raptors ended production at just 187 aircraft.¹¹ The B-2 Stealth Bomber was held to just 20 aircraft, a miniscule number of the planned 132. In light of this history, the Navy and Marine Corps are slated to purchase a total of 680 JSFs. According to Headquarters Marine Corps, the Marines need 420 JSFs to fill 21 active, 3 reserve, 2 fleet replacement, and 1 operational test and evaluation squadron.¹²

JSF Variant	Combat Radius (nm)	Internal Fuel (pounds)	Maximum g-rating	Weapons load (pounds)
F-35A CTOL	590	18,250	9.0	18,000
F-35B STOVL	450	13,500	7.0	15,000
F-35C Carrier	640	19,750	7.5	18,000

Table 1¹³

The Marines have requested the STOVL F-35B variant in order to have a complete aviation force that can operate on short runways of less than 3000ft—essential for an expeditionary niche and force. General James Amos, Commandant of the Marine Corps, recently pointed out, “[W]hen evaluating runways around the globe, there are 10 times as many 3,000-foot runways capable of handling the STOVL JSF variant as there are 8,000-foot runways required for conventional fighter aircraft.”¹⁴ However, the Harrier has operated at an expeditionary airfield in combat only three times throughout its service with the Marines.¹⁵ Mindful of its capability to operate in expeditionary environments, the Marines plan to use *Expeditionary Airfield 2000*.¹⁶ This expeditionary airfield with a 3,850-foot main runway has three sets of available M-31.¹⁷ It is capable of handling every naval TACAIR asset; it also provides assault support with the KC-130, and even the USAF C-17 Globemaster III. So the installation of

expeditionary arresting gear on short airfields enables the full complement of F/A-18's to take off and land with combat loads. For strategic flexibility, F/A-18 crews currently train for expeditionary missions. The short field expeditionary capability is also planned for the F-35C. Nevertheless, this mix of aircraft types and quantity is fluid—subject to program performance, defense appropriations, and the desires of Congress.

After 41 years of service to the United Kingdom, the Harrier GR9 flew its last flight in December 2010—deactivated because of limited budgets and the mothballing of their aircraft carrier the HMS *Ark Royal*.¹⁸ Furthermore, in October 2010, the British decided to switch from the STOVL F-35B to the carrier variant F-35C to support their future aircraft carrier designs. The United Kingdom invented the Vertical/Short Takeoff and Landing (V/STOL) technology. It has been the Marines' most important JSF partner. The U.K.'s change of plans does not bode well for the partnership security vested in the STOVL F-35B.¹⁹

Development of an Unmanned Aircraft Option

The Marine Corps' foray into unmanned aerial vehicles dates back to January 1987 when the RQ-2 Pioneer was integrated into the 1st Remotely Piloted Vehicle Company.²⁰ Since then, the community has expanded into three squadrons called Marine Unmanned Aerial Vehicle Squadrons (VMU). The fourth squadron, a reserve unit, will activate during FY11. The Pioneer, a workhorse of the VMUs, was finally retired in 2007 after 20 years of service that culminated with a single detachment construct outfitted with 5 Air Vehicles (AV) in each of the two VMUs. It was replaced by the RQ-7B Shadow 200, which resides in each VMU.

Enhancements with flight automation, reduction in maintenance, and improvements in training give the VMUs the capacity to operate the Shadow in three separate four-plane detachments for each VMU—essentially tripling capacity with the same manpower. The Shadow is a significant leap forward for the Marine Air Ground Task Force (MAGTF). It enhanced the VMU with communications relay capability, Infrared (IR) pointer, and enhanced optics. Above all, the addition of a laser target designator enabled it to successfully guide ordnance such as the AGM-114 Hellfire and GBU-12 (500lb) bomb in Afghanistan during 2010.²¹ Near-term improvements include re-winging the AV to increase its wingspan and adding two pylons capable of carrying canisters or weapons. Not only does this increase its endurance from six to nine hours, it also gives the Shadow a capability to carry two small weapons with individual weights of up to 25 lbs. If successful, it will be the first U.S. Naval UAS with weapons.

To meet the needs of Intelligence Surveillance and Reconnaissance (ISR) at the battalion and company levels for OIF, the Marine Corps obtained a fee-for-services contract in 2004 for a small UAS named the ScanEagle. With a length of four feet and wingspan of ten feet, ScanEagle has a superb endurance of over 15 hours. Due to its small payload capacity, it is limited to a day-only electro-optical (EO) or night-only IR camera configuration. It is expeditionary—capable of launch and recovery from austere locations and from ships in winds up to 40 kts.²² Controlled by civilian contractors and mission commanded by VMU Marines, the ScanEagle continues to be an important component of the MAGTFs many ISR requirements.

The Joint UAS Center of Excellence broadly categorizes UAS platforms by size and capability as referenced in Table 2.²³ The ScanEagle resides in Group 2. Shadow is

in Group 3. The Marine Corps seeks to have Group 3 and Group 4 UAS organic in the VMUs in order to support operational (Battalion/Marine Expeditionary Unit/Regiment) and strategic (Marine Expeditionary Force) levels of command.²⁴ Accordingly, they created the requirement for a Small Tactical UAS (STUAS) to provide an expeditionary and shipboard-capable Group 3 system that capitalizes on the success of ScanEagle. This system is initially designed to complement Shadow.

UAS Category	Maximum Weight	Normal Altitude (feet)	Speed (KIAS)	UAS Type
Group 1	0-20	<1200 AGL	100	Raven B
Group 2	21-55	<3,500 AGL	<250	ScanEagle
Group 3	<1320	<18,000 MSL	<250	RQ-7B Shadow STUAS
Group 4	>1320	<18,000 MSL	Any	VUAS Cargo UAS
Group 5	>1320	>18,000 MSL	Any	N-UCAS

Table 2

To fulfill this group 3 requirement, the Integrator UAS was developed and won the competition for the STUAS contract. The Integrator leverages successes of the ScanEagle and adds capability with its increased size. With its maximum weight of 135 lbs, length of 7.2 ft., and wingspan of 16 ft., it has an endurance of 24 hours. Unlike ScanEagle, it has an integrated EO/IR payload to provide day/night flexibility as well as the ability to image IR significant targets in the daytime. It also has a laser rangefinder for precise targeting, an IR pointer, and a heavy-fuel (JP-8) engine.²⁵ Significantly, its

heavy-fuel engine replaces the logistically challenging high-octane aviation gasoline used by the ScanEagle, Predator, and Shadow. Moreover, heavy fuel is preferred due to its high flashpoint; it's vastly safer for naval or shipboard operations. Integrator will be incorporated in the VMUs starting in FY12. The program of record through FY20 calls for fielding 32 systems of 4 Unmanned Aerial Vehicles (UAV)s per system for a total of 128 Integrators for the Marine Corps. These numbers will enable the MEU and joint task force commanders to keep STUAS detachments afloat.

Despite issues of costs, demands, and legal issues regarding private contractor support, the Marines added 81 personnel to each VMU to accommodate the STUAS. These personnel and equipment will start arriving in FY12. The 81 additional personnel are divided into nine separate nine-person Integrator detachments. Including the Shadow personnel and equipment structure, each active component VMU will consist of approximately 271 personnel formed in 12 detachments that fly a total of 48 UAVs.²⁶ This explosive growth in platforms and capability is welcomed after twenty years of evolution and ever increasing demands for UAS support.

To effectively lead these unmanned detachments and squadrons, the Marines finally approved the establishment of a UAS Primary Military Occupational Specialty (PMOS) in May 2010.²⁷ The community can now grow an officer corps from a second lieutenant to potential command at lieutenant colonel. The PMOS selection will commence during FY12. To expedite developing this MOS and capture the experience of available aviation experience, a transition/conversion board for EA-6B Electronic Countermeasure Officers and F/A-18D Weapons and Sensors Officers will meet in FY11.²⁸ Accordingly, after 16+ years of evolution, the first PMOS commander will

theoretically assume command of a VMU in 2028—well after the retirement of the current tactical aircraft fleet. One can only imagine what technology will become available during this time. With a foundation established for personnel and systems, the community is well-suited for increased tasking and expanded responsibilities.

Technology to Enhance the Unmanned Mission

The current VMU mission is to conduct air reconnaissance, analyze and synthesize information, control indirect fires, and conduct terminal guidance operations.²⁹ This current mission set is consistent with the physical capacity of the fielded systems in 2007. Improvements in capacity and capabilities will surely expand the VMU mission.

Through the employment of its existing aviation platforms, the MAGTF is supported by the six functions of Marine Aviation: assault support, anti-air warfare, offensive air support, electronic warfare, aerial reconnaissance, and control of aircraft and missiles. Since UAS lack an air-to-air radar and complementary dynamic flight envelope, Marine Aviation cannot currently conduct traditional anti-air warfare in fighter-to-fighter combat. In fact, on 23 December 2002, an Iraqi MiG-25 Foxbat and US Air Force Predator did exchange air-to-air missile shots—the Predator lost.³⁰ According to a RAND study, reaction times and dynamic situational awareness are not yet sufficient.³¹ Since the Marine Corps has recently invited competitive contracts for an unmanned helicopter to deliver cargo, it is envisioned that UAS will be able to assist and support the MAGTF with five of these functions.³² Finally, innovation and future technical achievements will most likely enable the UAS to reliably expand into the air-to-air combat role. When this occurs, the Marine Corps should embrace it.

The Quest for a Group 4 UAS

The FY2011 Marine Aviation Plan indicates the RQ-7B Shadow will be replaced by a Group 4 UAS beginning in FY16. This UAS is planned to support “joint forcible-entry operations delivered from sea bases.”³³ The Marine Expeditionary Force and VMU Operational Advisory Group have established performance requirements for operational and strategic support to include: all-weather, 1350nm combat radius, 240+ knots airspeed, and 10+ hour time on station. This is three times the radius of an F-35B, the speed of an MV-22, and a greater endurance than any mission typically flown by a Marine aircraft.³⁴ The capabilities and mission sets include electronic attack, persistent strike, ISR, full-motion video, targeting, weapons employment, synthetic aperture radar, ground moving target indicator, wide airborne area surveillance, signals intelligence, and communications and data relay.³⁵ If these requirements can be met, this platform will “meet the needs of Marine Corps and joint task force commanders.”³⁶

The weapons potential of UAS is evolutionary. When the press reports on U.S. missile strikes, they usually attribute them to the Hellfire. But for many targets, the Hellfire is too large, too noisy, and too expensive. New weapons, such as the Griffin, employed by the USAF Predator and Marine KC-130J, greatly increase the quantity and precision of airborne weapons. Additionally, they give the United States leverage by reducing collateral damage and non-combatant deaths—strategically vital for U.S. foreign policy and acceptable interventions.

To provide vision to support expeditionary maneuver warfare, General Hagee published *A Concept for Distributed Operations* in 2005.³⁷ This concept tactically disperses fighting maneuver elements across the battlefield so that they are operating

independently from adjacent friendly forces. Essentially, enabling individual companies and platoons to occupy territory that would normally be held by an appreciably larger force is the primary requisite of the Distributed Operations design. These dispersed units assume risk because of their dependence on inorganic and joint fire support. A RAND study on aerial firepower that supports distributed Counterinsurgency Operations (COIN) by small light units asserts that “[I]n the event of ambush or other emergency capability to have overhead or precision indirect fires available twenty-four hours a day would help mitigate this concern.”³⁸ Systems such as the Global Positioning System (GPS)-guided High Mobility Advanced Rocket System and the GPS-guided M982 155mm Excalibur round have greatly increased the range and precision of all weather indirect fires. However, limitations on ground- based fires include time lost generating GPS-quality coordinates, clearing airspace, and inability to strike moving targets. These limitations put light COIN units at risk, and this risk can be mitigated if these units are supported 24/7 by overhead airborne fires.

Based on recent combat experience in Iraq and Afghanistan, armed UAS such as the Predator and Reaper carrying Hellfire and laser guided bombs such as GBU-12s have become a weapon of choice for many infantry units. Time on station and situational awareness are critically important to local commanders. The ability of an armed UAS to stay on station for many hours, often ten or more, enables the crews to gain knowledge of the supported unit, develop the situation, mitigate risk, and retain the fuel and time to deliver ordnance if required. Many fixed-wing pilots have only from 30 to 60 minutes on station before they must leave the battlespace to refuel or land. Often this is not enough time to support COIN units in low-intensity conflicts. Rotary-wing

assets do not fare better. They may have an increased time on station; however they are limited in speed. They are exposed to ground fire. Their rotor noise gives the enemy time to take cover.

The effort to add weapons to the Shadow was initiated because of the missed opportunities to strike targets in both OIF and OEF when airborne ordnance was unavailable and ground-based indirect fires are prohibited because of problems in timing, airspace clearance, or collateral damage. Marine aviation leaders did not seek to adapt proven programs such as the Air Force Reaper or Predator, or even the Army Grey Eagle, due to the costs of transitioning to other platforms and manpower constraints. These Air Force and Army platforms takeoff and land on normal hard runways. The Marines would prefer to leverage these programs for support than own them. The expeditionary niche for a VUAS was deemed more appropriate for the Marines' role in the greater joint force.

So the Marine Corps developed an ISR/weapons mission kit for their KC-130J Hercules in response to a 2008 urgent universal needs statement requesting a limited long-duration ISR and Close Air Support (CAS) platform to support combat operations in Afghanistan. Called Harvest Hawk, the mission kit modifies the aerial refueling aircraft by removing one of two refueling pods. It adds a targeting pod and requires an additional crew member to employ the aircraft's precision munitions: the Hellfire, Griffin, and Viper Strike.³⁹

Deployed to Afghanistan's Helmand Province, the crew of a Harvest Hawk equipped KC-130J successfully engaged enemy forces in October 2010.⁴⁰ Nine additional kits will be procured—three for each active duty squadron. This quick

response to an urgent need certainly demonstrates the flexibility of Marine Aviation. However, it is troubling that the ISR/CAS requirements of engaged infantry units are not being met by the current joint organic rotary and fixed-wing attack platforms. Perhaps the joint armed UAS support is simply insufficient.

Counterinsurgency warfare requires responsive aviation fires. This airborne support cannot be delivered by conventional scheduled periods of CAS. Moreover, standard operating procedure calls for tethering two KC-130Js to a Marine Expeditionary Unit (MEU) in order to provide aerial refueling and logistics support on an on-call basis. MEU commanders, lacking armed ISR and an organic Group 3 or 4 UAS, request the Harvest Hawk to support their Marines.

Amphibious Capability

As an expeditionary force operating from the sea, the Marines rely on amphibious shipping provided by the Navy. The strength of the force resides in its ability to project power from the sea and sustain personnel ashore as the nation's force in readiness. For example, over the last 20 years, "Marines have conducted 108 amphibious operations of all types."⁴¹ These are accomplished via two primary methods—airlift and by sea. Marine and Navy medium- and heavy-lift helicopters provide the majority of the airlift mission. Well decks of ships provide platforms such as the Landing Craft Air Cushion (LCAC) and Landing Craft Utility (LCU) to move ashore large combat equipment, such as tanks and bulky supplies.

In a MEU, three types of ships make up the force to support the embarked battalion landing team, the aviation combat element, and the combat logistics element. They are the amphibious transport, dock (LPD); the landing ship, dock (LSD); and the

amphibious assault ships (LHA/LHD). Fixed-wing aircraft currently operate off the LHA (amphibious assault ship - general purpose) and LHD (amphibious assault ship - multipurpose). Both the LHA and LHD can host a mix of 31 rotary-wing, tilt-rotor, and fixed-wing aircraft.⁴² This mix normally includes 12 MV-22 Osprey or CH-46E Sea Knights, 4 AH-1W/Z Cobras/Viper, 3 UH-1N/Z Huey/Venom, 4 CH-53E Super Stallions, and 6 AV-8B Harrier IIs.

The current inventory of amphibious assault ships includes two LHAs and 8 LHDs. Two additional amphibious assault ships without well decks are in development: LHA-6 is scheduled for IOC in FY14. The LHA-7 contract will be awarded in FY11. These two ships are essentially small aircraft carriers—all of their ship-to-ship or ship-to-shore movement will come via airlift. Furthermore, an additional class, the LHA(R)—a replacement for the LHA class—is designed to enhance aviation capacity by providing a larger hangar and increased aviation fuel capacity in lieu of well-deck capability. However, these requirements may be changing: General James Amos, Commandant of the Marine Corps, believes the lack of a well deck on an amphibious ship is a mistake. Referring to the LHA-6 and LHA-7, he recently observed, “[T]hese platforms are maximized for aviation, and I believe it is *essential* that a well-deck be reintroduced into future development of this class of ships at the earliest opportunity.”⁴³ The Marines hope to maintain strength at eleven big-deck amphibious ships, most with well-decks.⁴⁴ This doubles the amount of fixed-wing capable ships in the U.S. Navy.⁴⁵ The LHA class and newer versions will be able to embark the F-35B. The Naval Aviation Plan of 2032 foresees an embarked aviation combat element containing 6 F-35B, 12 MV-22, 4 CH-53K, 4 AH-1Z, and 3 UH-1Y—the same as current numbers.⁴⁶

The 15,000 to 20,000 Marines in the Marine Expeditionary Brigade (MEB) require 14 to 17 amphibious ships—including three to five LHA/LHD/LHA(R) class.⁴⁷ Because of host-country restrictions, or prohibitive interference, or risk, the ACE may elect to stay afloat. Focusing on the Maritime Prepositioning Force (Future) (MPF(F)), a RAND study concluded that sustaining a MEB ashore from a sea-based ACE would not permit sustained operations of JSFs aboard the flight decks of the LHA/LHA(R). The study does acknowledge that “small numbers of JSF’s could still use the MPF(F) as a base for refueling and rearming or emergency landings.”⁴⁸ The study found that the ships do not have the deck space, fuel, or munitions to effectively sustain the tactical aviation force. This presents problems in a denied environment. It is problematic for a sea base when a portion of its fixed-wing, rotary-wing, or rotorcraft aviation assets cannot disembark. The study concludes that flight operations would be overwhelmingly needed to support the MEB’s 20 CH-53Ks and 48 MV-22s.⁴⁹

Permissive operating environments, as in OIF, allow amphibious ships to disembark rotorcraft and serve exclusively as TACAIR carriers. This option reduces shore-base sustainment and possible airfield congestion by joint forces or other Marine aircraft. It gives commanders flexibility. Yet it is only feasible if the rest of the aviation combat element is ashore. And this option is not always available.

Insightfully, the RAND report assumed that the MEB would be supported by six UAVs—but it offered no specifics regarding service or type/model/series. Looking beyond pure military missions, the report suggested that the sea-base could be used for UAVs to support law enforcement, local and advisory forces, and others.⁵⁰ This is certainly consistent with the historic role of the amphibious force: 74% of amphibious

operations since 1989 have been non-kinetic.⁵¹ These operations ranged from disaster relief to noncombatant operations. Surely many, if not most, MEU missions in littoral environments will be non-military.

Lieutenant General Flynn authored a seminal work titled *Amphibious Operations in the 21st Century* in order to “inspire an intellectual renaissance in amphibious thinking.”⁵² He believes amphibious aviation enablers such as helicopters (CH-53K) and tilt-rotor aircraft (MV-22B) are absolutely essential. But he makes no mention of the JSF or AV-8B. His vision raises concerns that air and surface fires must be available under *hostile or uncertain conditions*. Flynn suggests that the lack of a modern battleship has required the force to rely too much on the expensive, fair-weather aircraft of the aircraft carrier.⁵³ Finally, he recommends unmanned aerial vehicles as one of the solutions to the demanding fire-support problems.⁵⁴

STOVL Limitations

Marine aviation has operated fixed-wing aircraft since 1912—59 years without V/STOL capability. Seeking a way to directly support amphibious operations and protect its organic fixed-wing arm, the Marines decided to focus on the unique capabilities of the British-designed V/STOL AV-8A Harrier. Marine Attack Squadron 513 transitioned to them in 1971 and deployed aboard the USS *Guam* the following year.⁵⁵ The upgraded AV-8B Harrier II replaced the AV-8A and saw its first deployment in 1987 aboard the USS *Belleau Wood*, then experienced its first combat during Operation Desert Storm in 1991.⁵⁶

The V/STOL aircraft operating off amphibious ships do have some limitations in comparison to shore-based and carrier aircraft. In a normal embarked detachment of

only six aircraft, its support to the MAGTF is limited. Amphibious assault ships do not conduct continuous flight operations due to limitations in personnel and resources. Fixed-wing aircraft normally operate in sections, which constrains flexibility. In remote locations, the STOVL aircraft will not likely have in-flight refueling available, so they will have to return to the ship to refuel. This limits their time on station. On the other hand, this does give the STOVL aircraft the ability to rearm if the pilot has expended ordnance.

Table 3 depicts differences in MAGTF ship and land operations according to type of airframes. Aircraft operating ashore historically provide more support to ground forces because they operate without shipboard constraints. They are not constrained by specific land times; they need less fuel for similar missions; they can return bombs to their landing site, unlike their naval counterparts; they are not constrained by reduced maximum permissible landing weights. In other words, aircraft have to be considerably lighter when landing aboard ship—and this comes at the expense of fuel or ordnance. During OIF, 60 F/A-18C/D's based at Ahmed Al Jaber Airfield, Kuwait, flew over 120 sorties per day and employed 4.2 million pounds of ordnance.⁵⁷ The AV-8B Harrier had 16 A/C based with the Hornets at Al Jaber, with another 60 aboard amphibious assault ships in the Persian Gulf. These ships served as *Harrier carriers* by disembarking their helicopters to support the MEF ashore. The 76 AV-8Bs flew over 3000 flight hours in nearly 2000 sorties and dropped over 750,000 pounds of ordnance during OIF—their sorties and hours are for a hypothetical 12-plane squadron.⁵⁸ VMFA-323 flew from the USS Constellation operating in the Persian Gulf. Much like the F-35B, the V/STOL

aircraft will fly less hours and carry less ordnance in comparison to traditional strike fighters.

A/C Type	Operating Base	Sorties	Flight Hours	# of Ordnance
F/A-18C	CVN			364,000 ⁵⁹
F/A-18C	Land	502	1053	735,000
F/A-18D	Land	558	1440	803,000
AV-8B (12 A/C)	Ship	315	475	120,000

Table 3

During Operation MOSHTARAK, the battle for Marjah, Afghanistan, the AV-8B landed just minutes away from the fight at Forward Operating Base Dwyer to rearm and refuel. This close-in refueling yielded a 10% increase in time-on-station for the supported NATO International Security Assistance Force. Although highly lauded by the community, the practice was halted when aircraft were downed for maintenance at the FOB without parts, equipment, and appropriate personnel to fix them. An inherent risk of expeditionary operations includes such issues as proximity to refueling and repair sites.⁶⁰

Develop Group 4 VUAS with Integration of JSF

Regardless of the future of the JSF and the STOVL force, the Marine Corps should embrace the VUAS as part of the expeditionary force. The uncertainty of the battlefield, distributed operations, and the ground commanders' requirements unquestionably affirm that the current organic tactical aircraft and efforts to build a joint aircraft capability are not enough. The roadmap for VUAS should include integration with the JSF. Data-sharing between VUAS will ensure the MAGTF obtains the most

responsive support. The mission software on all models of the JSF is identical. All integration initiatives seek to ensure compatibility and strategic flexibility for the joint forces. These requirements are absolutely essential. Operating independently, but electronically linked to other aircraft, is a combat multiplier. For the traditional fixed-wing aircraft, a UAS tether is like adding another wingman with greater endurance, limitless access to information, alternate means to communicate, and high situational awareness.⁶¹ Successful integration will make expeditionary leaders more confident that the F-35As and F-35Cs operated by USAF, USN, USMC, and coalition partners will operate seamlessly with the MAGTF—thereby reducing risk and sole dependence on the F-35B.

Future Options for Marine Corps Fixed-Wing

The JSF has also been called the “last manned fighter” by leaders such as Admiral Mike Mullen, Chairman Joint Chiefs of Staff.⁶² This view is increasingly embraced throughout the strategic operating environment. The Navy is supporting the development of the X-47B Unmanned Combat Aircraft System as it explores the feasibility of a low-observable unmanned carrier-based attack aircraft.⁶³ In fact this aircraft successfully completed its inaugural flight on 4 February, 2011.⁶⁴ The USAF has publically announced an optionally manned 6th-generation fighter and bomber. Long-time industry leaders, the Israelis plan to reduce their manned platforms to only 50% of the fleet by 2030.⁶⁵ Services and nations, it appears, are posturing in accord with Admiral Mullen’s vision.

The future of Marine Corps Aviation’s fixed-wing fighter attack aircraft will not be known for some time. In fact, “the Department of the Navy, which includes the Marine

Corps, is now studying a possible mix of F-35B and F-35C aircraft for the Marines.”⁶⁶

Regardless, the current TACAIR force will eventually dwindle due to airframe fatigue and parts obsolescence. The F-35B may develop as planned and fill all 27 squadrons with STOVL aircraft. The service may acquire a mix of F-35B and F-35C, thereby increasing capability and aircraft carrier integration with the Navy. The F-35B may be cancelled; the Marines could then acquire F-35C and forego fixed-wing aircraft aboard amphibious ships. The Marines may buy the F/A-18E/F and miss the JSF. Lastly, the Marine Corps could continue to fly legacy aircraft, fail to acquire the JSF, and proceed to build an UAS attack-capable force.

Choose F-35C and VUAS

The fiscal realities of the current operating environment may force the DoD to make unprecedented cuts to programs and service capabilities. The jury is still out on whether Marine Aviation will acquire STOVL aircraft. The loss of the F-35B can be mitigated through innovation and capabilities found in the future VUAS. A better alternative for the force is to preserve the capabilities in the JSF with the purchase of the F-35C, then place detachments of VUAS-equipped VMUs aboard amphibious ships. The F-35C has a 42% greater combat range and 20% heavier payload than the STOVL F-35B because it carries 46% more internal fuel than the STOVL F-35B. This is significant. The Marines can operate according to their expeditionary roots and use fixed-wing aircraft much as it employs today's F/A-18s and EA-6Bs on long runways, short expeditionary airfields, and as part of carrier air wings. The Marines have been very successful with this employment strategy, so continuing as we are is a viable strategy.

Increasing the VUAS numbers beyond what is planned will offset the requirement to fill the decks of the amphibious ships. The JSF transition plan converts seven 14-plane VMA AV-8B squadrons to seven 16-plane VMFA JSF squadrons. This transition preserves the squadron's ability to split into six-plane amphibious ship detachments or ten-plane expeditionary detachments. The F/A-18-equipped VMFAs transition from twelve aircraft to ten—on the premise that the JSFs are more reliable. A non-STOVL force reduces the requirement for the six-plane detachments in the seven VMA replacement squadrons. The Marines can use these 42 to offset the manpower and funding required for a VUAS. According to the most recent estimate, JSF will cost approximately \$109 million per aircraft.⁶⁷ So the non-STOVL force would save \$4.5 billion in aircraft alone. This capital investment in the Marine VUAS program would sufficiently equip the VMUs with a platform that would meet their amphibious requirements. This investment would enable the VMUs to increase in numbers and size and provide the MAGTF with an airframe that has more persistence and support potential than the STOVL F-35B.

Conclusion

The Marine Corps prides itself on its niche expeditionary capability. It vigorously monitors emerging threats to the Marines' institutional concepts, programs, and capabilities. A decision will most likely be made in the next two years on the future of the STOVL F-35B JSF. Accepting a more capable F-35C JSF and substituting the F-35B with a VUAS offers an uneasy short-term paradigm shift. However, this course of action will ultimately provide more capability and support to the MAGTF.

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